HUMAN AND ROBOTIC MISSIONS COMBINATION IN LUNAR EXPLORATION ROADMAP.

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Introduction: According to the strategic documents for space activities of Russian Federation the main direction of prospective missions after 2025 is the Moon. Some elements of Russian lunar program are planned in the actual space program for 2016-2025, for instance robotic spacecrafts, crew and launch vehicle. Other elements are now under discussion to become a part of a lunar program. Robotic exploration of the Moon is an essential part of the exploration roadmap. It enables lunar research program and prepare us for human missions through key technologies testing. On the other hand, development of a scale lunar base will be impossible without not only robotic spacecraft but also human missions.

The Roadmap of Lunar Exploration: The possible Russian roadmap of lunar exploration includes four major phases, that are based on balance between human and robotic missions.

The first phase is preparative and based mainly on the first robotic spacecrafts, that will investigate the most interesting lunar landing sites and demonstrate a number of technolohies. During this phase development of Russian space transportation system for human and cargo delivery will be developed and critical technologies will be tested.

On the second phase the initial lunar communication and navigation systems will be deployed. The first Russian human mission on the lunar orbits will be lauched. The technology of automatic lunar regolith return to Earth will be tested.

The third phase is a human lunar base development in its' minimal configuration and infrastructure development for resources manufacturing, scientific and experimental complexes development, resource utilisation for the purposes of manned lunar base.

The fourth phase is a lunar base enlargement and closed-loop life-support system development, that will function with the use of lunar resources; propellant components production and its' usage in Russian space transportation system; oxygen, water, metals, constructional materials recovery.

This roadmap is presenting a wide range of opportunities for moon exploration by virtue of robotic and human spacecrafts combination.

The Possibilities of International Partnerships: The many years of human and robotic space exploration shows that the most sustainable and cost effective way to explore space and to the greatest benefits to Earth, is to establish partnerships. Based on ISS experience, the future Lunar Orbital Platform – Gateway is now under discussion. In Russian lunar exploration strategy the lunar orbital platform is not the core element but it enables the opportunity to expand the program of scientific experiments.

Collaborative design of payload for lunar robotic spacecraft also brings powerful capabilities for international partnership. HERACLES mission, wich goals are very similar to russian "Luna" robotic missions, is an example for such collaboration.

Key Technologies Development: The roadmap of lunar exploration is considering the key technologies development. The task of key technology areas specification now is solving by the International Space Exploration Coordination Group (ISECG), in which Russia also participates. The status of this work is documented in ISECG's Global Exploration Roadmap (GER) [1]. According to this investigation we can place emphasis on the next key technology areas and its' subareas that are critical for the moon exploration: launch propulsion systems, space power and energy storage, robotics, autonomous systems, communications and navigation, entry, descent, and landing systems, life support, habitation systems, in-situ resource utilization.

Planned Robotic Missions: Nowdays a number of lunar robotic missions are preparing for the first phase of Moon exploration [2].

Luna-25. It is a lightweight robotic spacecraft for a complex research in the circumpolar lunar region. It is preaping for soft-landing technology testing.

Luna-26. This orbiter is supposed for a global observation and lunar resource survey, for supporting networking with descent spacecrafts, and for supporting communication with Earth.

Luna-27. It provides highly-precise landing in difficult lunar geological conditions. It provides a scientific harware complex, including lunar manipulating complex for soil sampling and investigation.

Luna-28. The main project goal is to deliver vacuum-packed lunar ice sample with undisturbed structure on Earth for further investigation in ground research centers. Also there is an option to dock it to the Gateway for on-station samples research.

Planned Human Missions: The second phase enables annual human missions to the lunar surface. During these first short-duration missions crews will conduct research on the most interesting lunar landing sites, and a program of full-scale scientific experiments will be evolveded. Using the possibilities of special robotic means crews will remotely prepare lunar infrastructure for long-duration missions.

References:

[1] Global Exploration Roadmap (2018),
[2] K. Raykunov, M. Danilova, Dr. G. Karabadzhak (2017) GLEX-2017, Paper ID 37020.